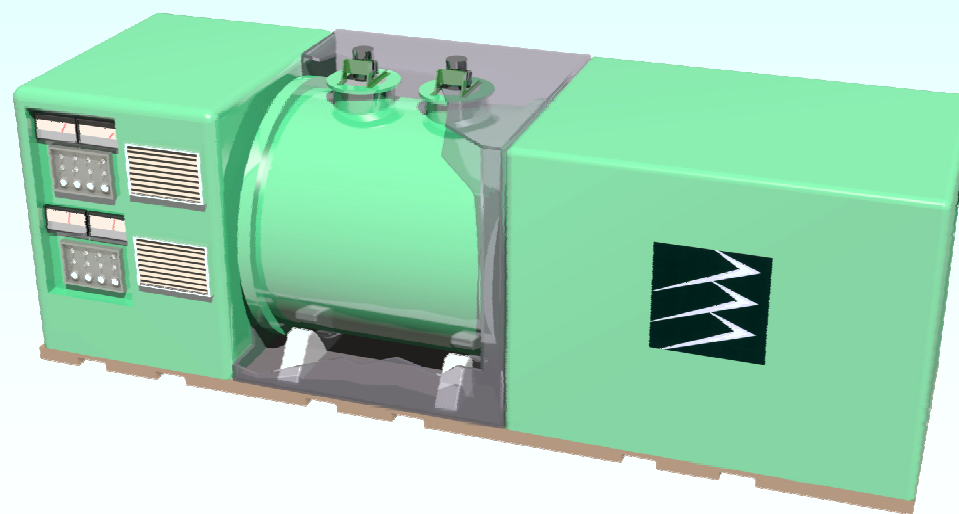


POWERING A CLEANER FUTURE

# **250 kW Fuel Cell Demonstration Using Coal Mine Methane**

**North American Coalbed Methane Forum**

**April 26, 2001**



# FuelCell Energy

## *Who is FuelCell Energy?*

We intend to be the leading manufacturer of fuel cell products for the global stationary power generation market

- Our Direct FuelCell® products will serve:
  - small distributed generation
  - large distributed generation
  - marine/diesel
- The markets are very large
- We have a clear path to these markets

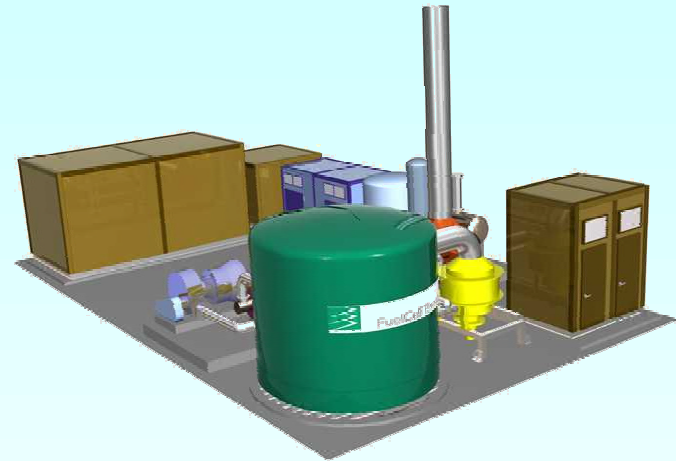


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# ***FCE DIRECT FUELCELL® PRODUCTS***



***300 kW***



***1.5 MW***



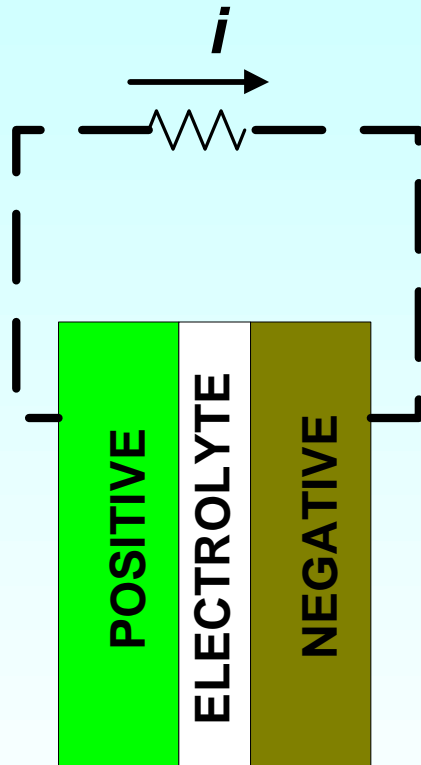
***3 MW***



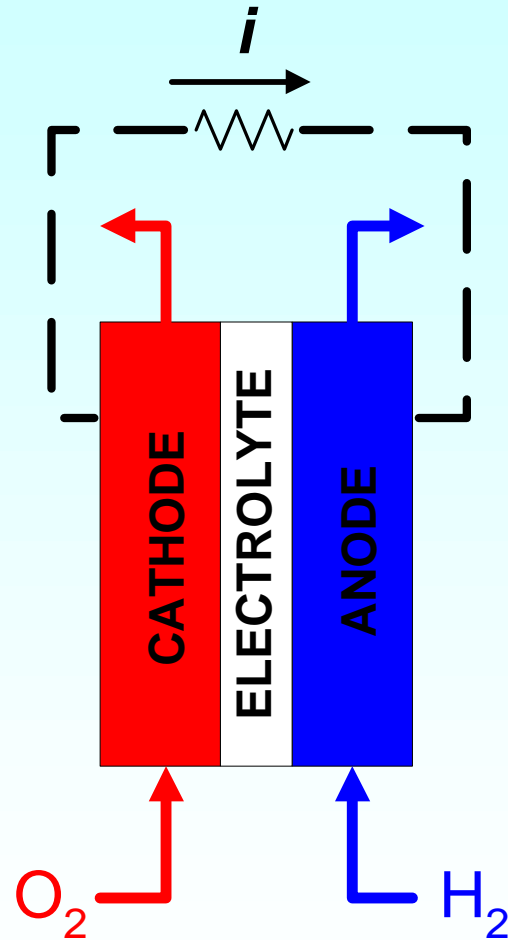
**FuelCell Energy**

MO2233E  
12800

# *FUEL CELL VS BATTERY*



**BATTERY**



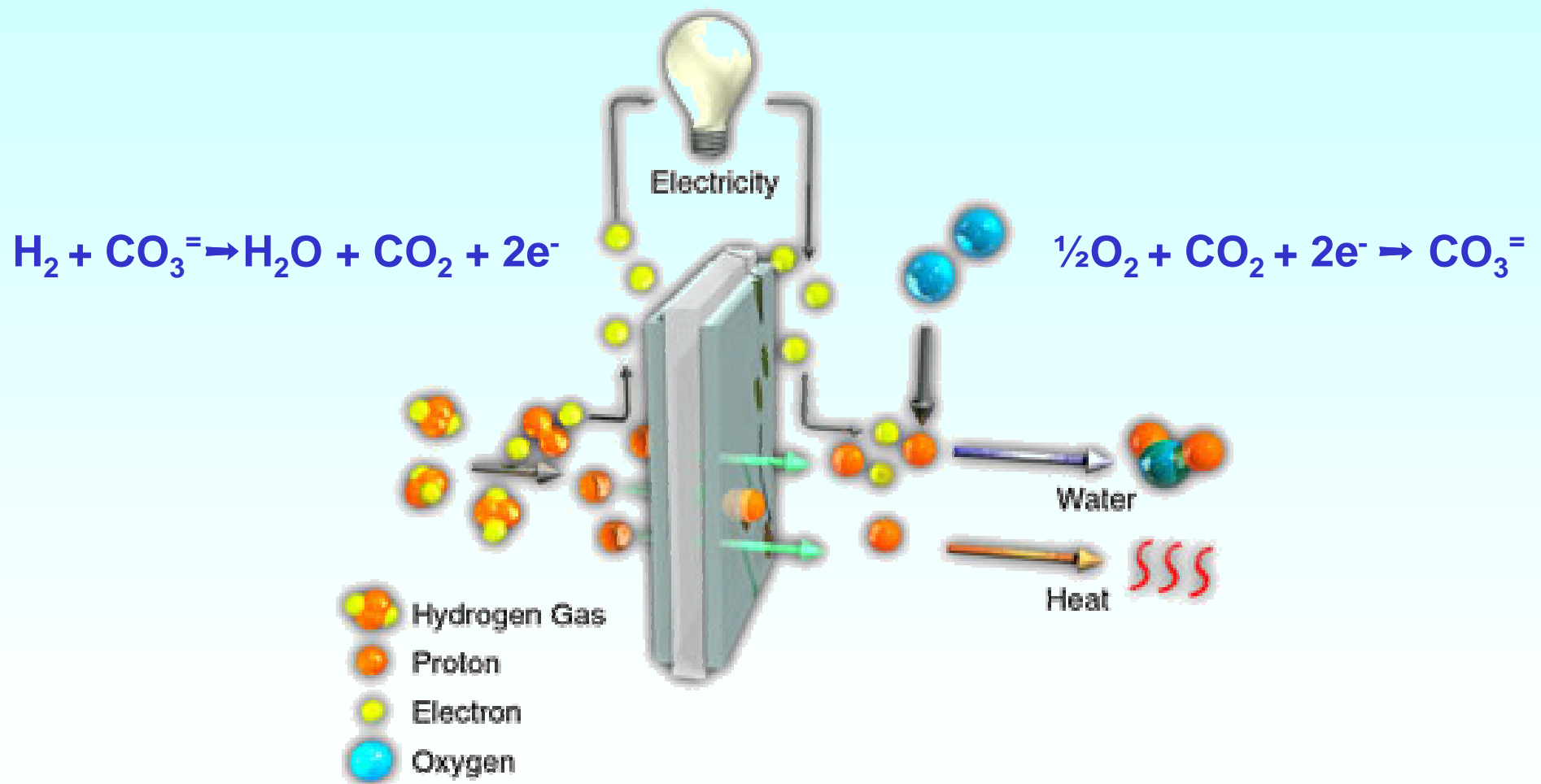
**FUEL CELL**



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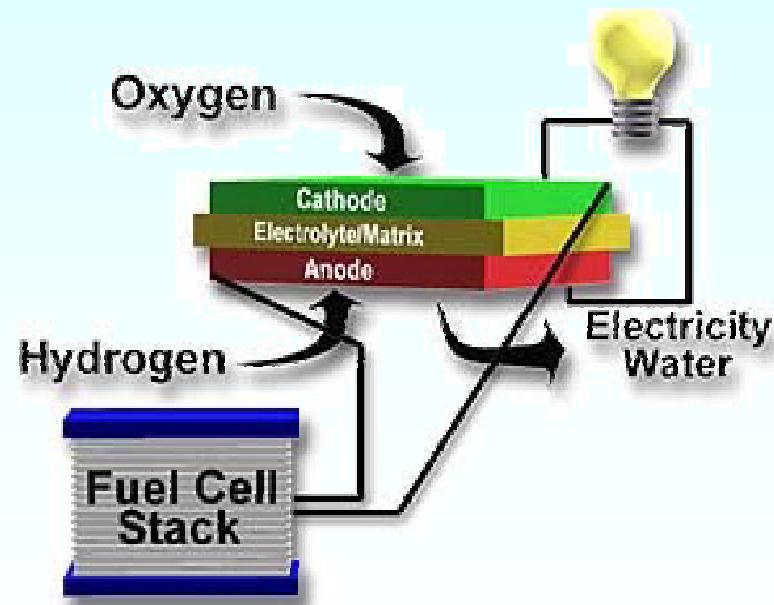
# FUEL CELL OPERATION



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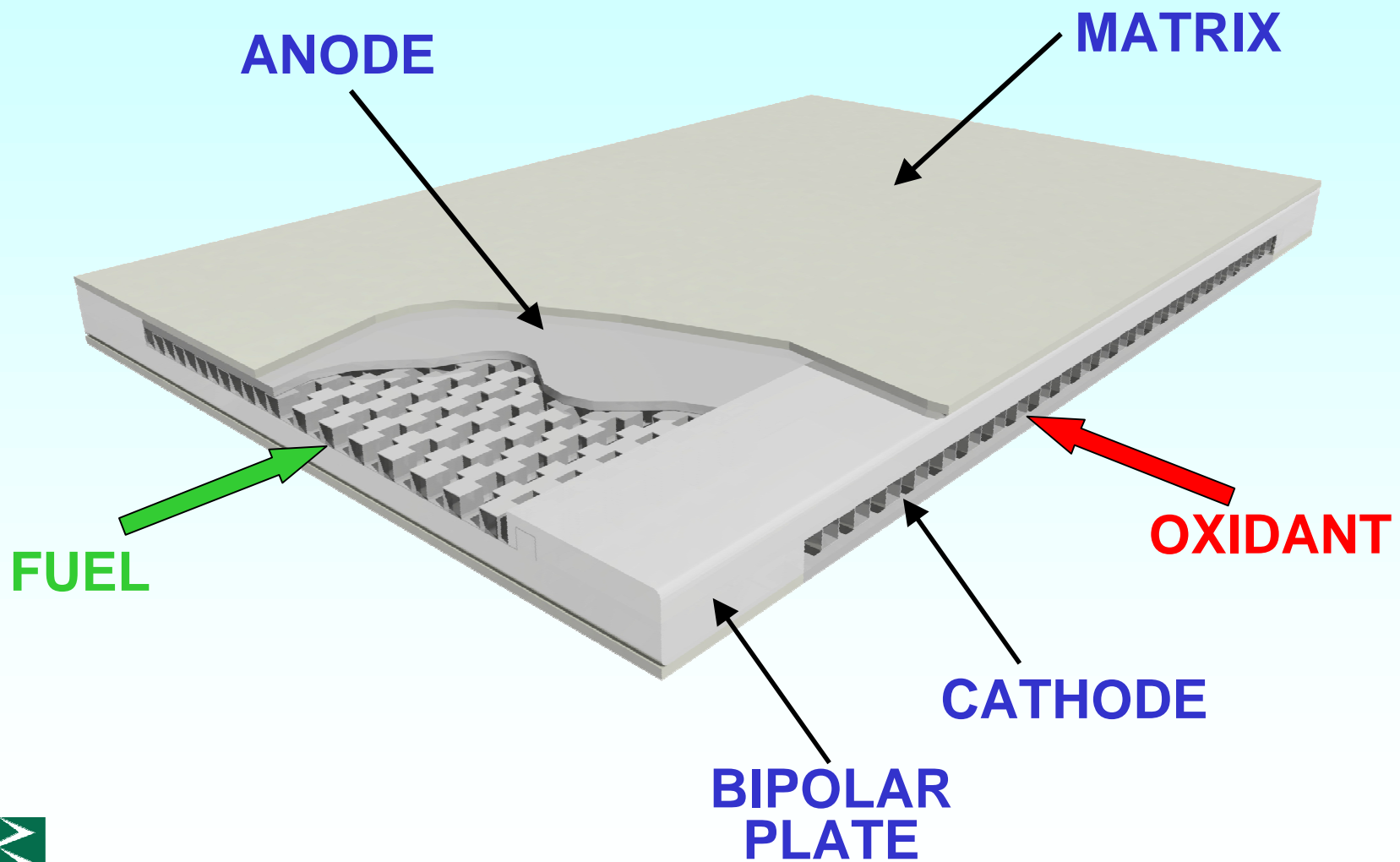
# ***FUEL CELL CONCEPT***

- INCREASE VOLTAGE TO USEFUL LEVELS
- BUNDLE OR STACK MANY ELECTRODE/ELECTROLYTE ASSEMBLIES TOGETHER
- BUILD “STACK”



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# ***FUEL CELL CONFIGURATION***



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MO2402  
7899

## ***FULL-SIZE DFC STACK***



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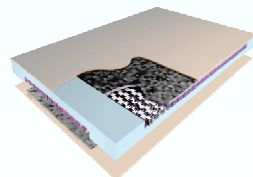
# OUR PLANNED PRODUCTS

## Product Design is Scalable

- Building block approach provides scalability and a standardized product to manufacture



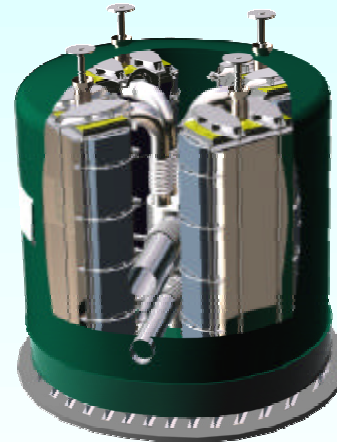
**Module**



**Fuel Cell**



**Stack**



**Module**

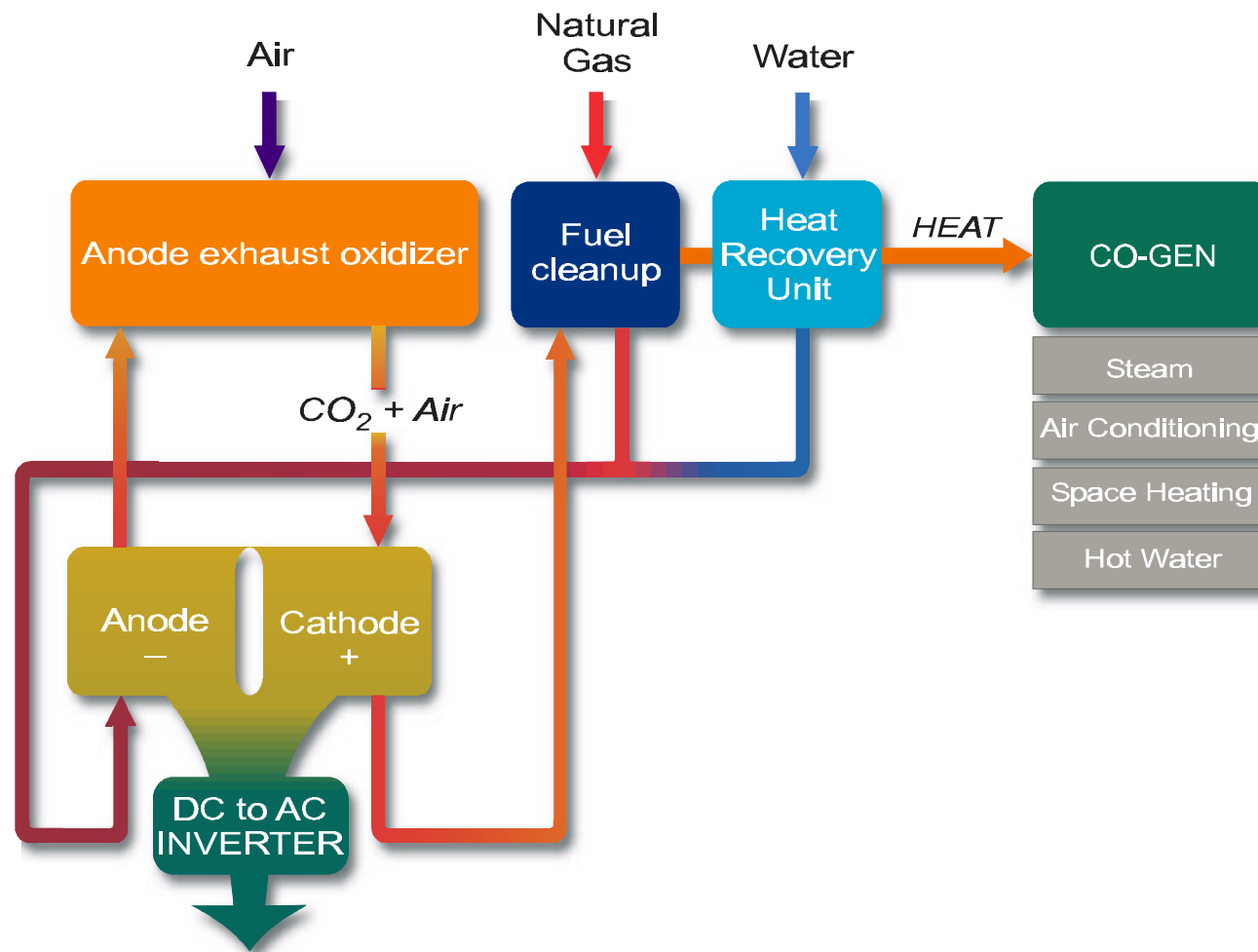


**The Power Plant**



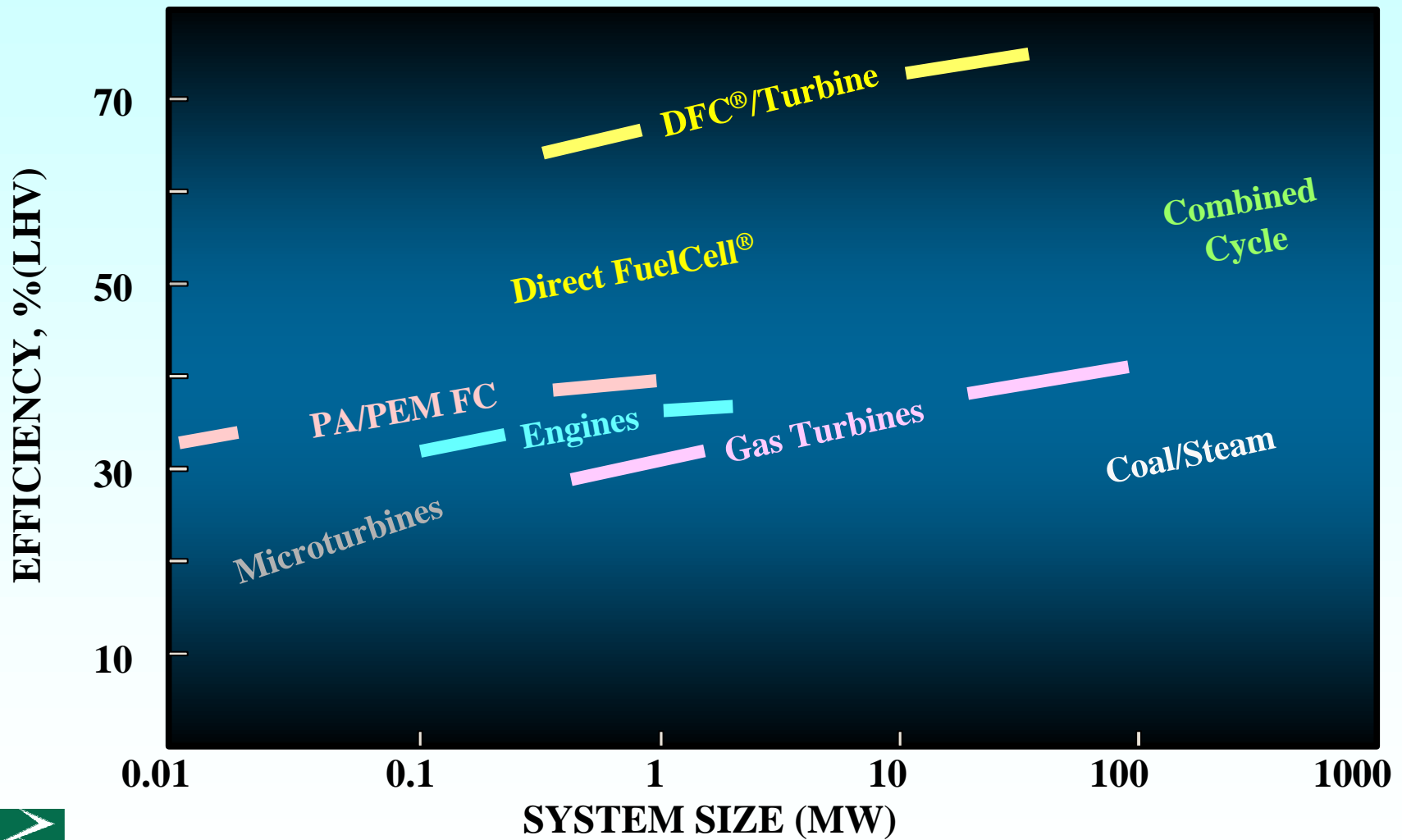
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# SIMPLIFIED FUEL CELL SYSTEM SCHEMATIC



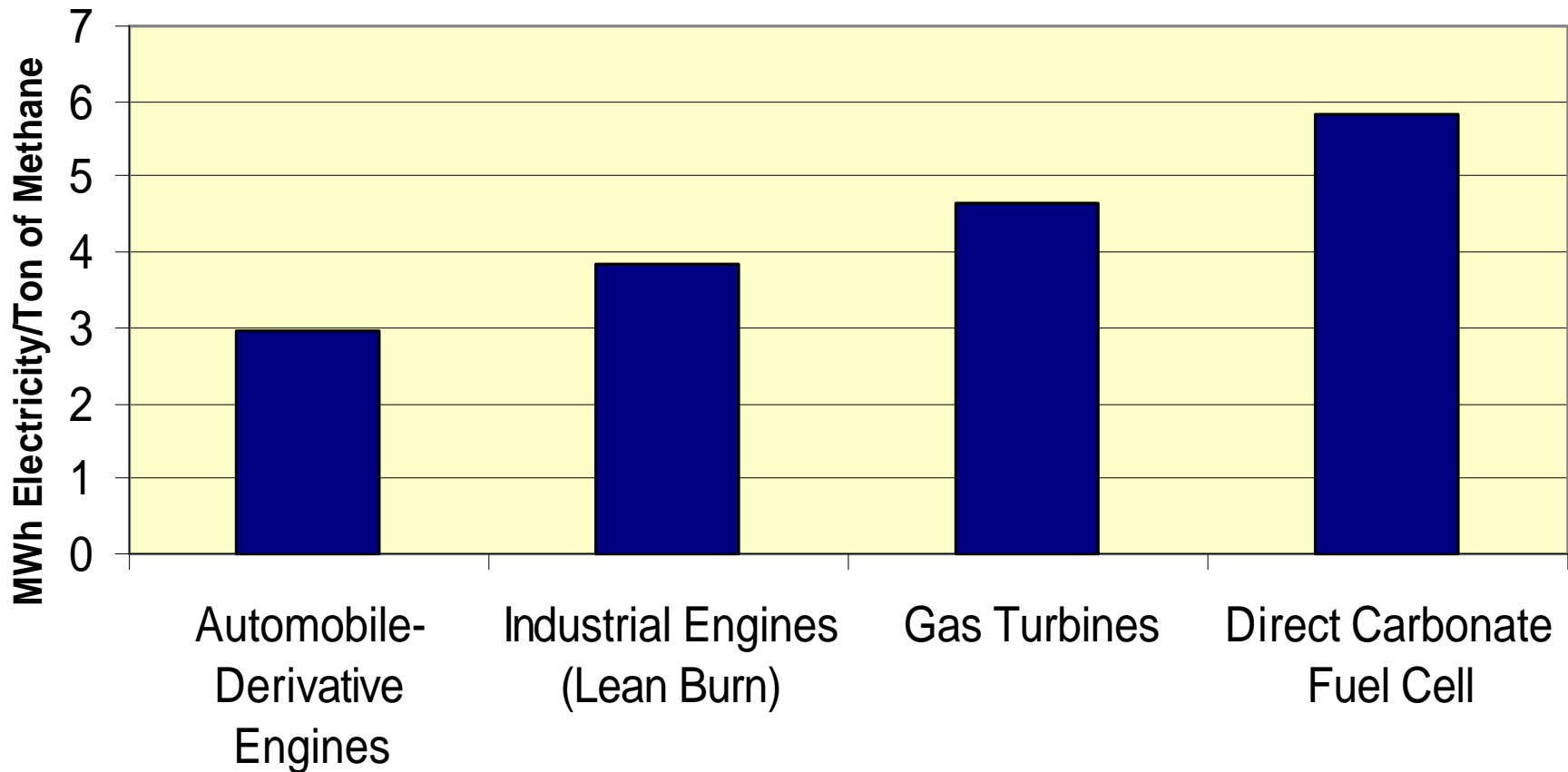
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# COMPARATIVE EFFICIENCIES OF ELECTRIC POWER PLANTS



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# ***EFFECTIVENESS OF VARIOUS TECHNOLOGIES IN UTILIZING COAL MINE METHANE***



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# COMPARISON OF POWER GENERATION ALTERNATIVES

	Performance Efficiency (1) LHV	Emissions		Capital Costs (2) \$/kW	O&M Costs (3) mills/kWh	Cost of Electricity (4) mills/kWh
		CO lbs/MWh	NOx Lbs/MWh			
<b>Internal Combustion Reciprocating Engines</b>						
Automobile-Derivative Engines	26% - 31%	3-6	12-71	500	8	15
Industrial Engines (Lean Burn)	31% - 34%	7.4	4.4	800	10	21
<b>Gas Turbines</b>	40%	3	12	1,000	10	23
<b>Direct Carbonate Fuel Cell</b>						
AC Power	50 - 60	0.006	0.0004	1200	10	26
DC Power	52-63	0.006	0.0004	1100	10	25

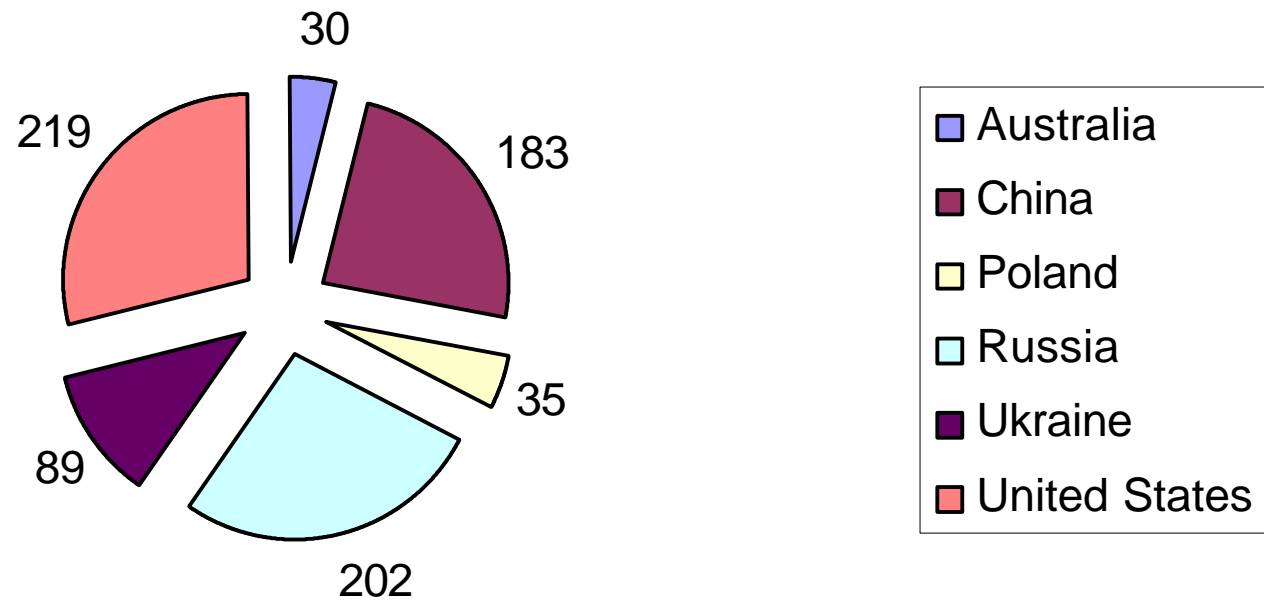
- NOTES:
- (1) Performance Efficiency = Percent of fuel energy converted to electric power
  - (2) Capital costs included electrical switchgear
  - (3) O&M Costs include operation and maintenance plus overhaul replacements
  - (4) Based on 95% load factor



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# ***CURRENT COAL MINE METHANE POTENTIAL IN SELECTED COUNTRIES BASED ON UNUTILIZED CAPACITY OF CAPTURED METHANE***

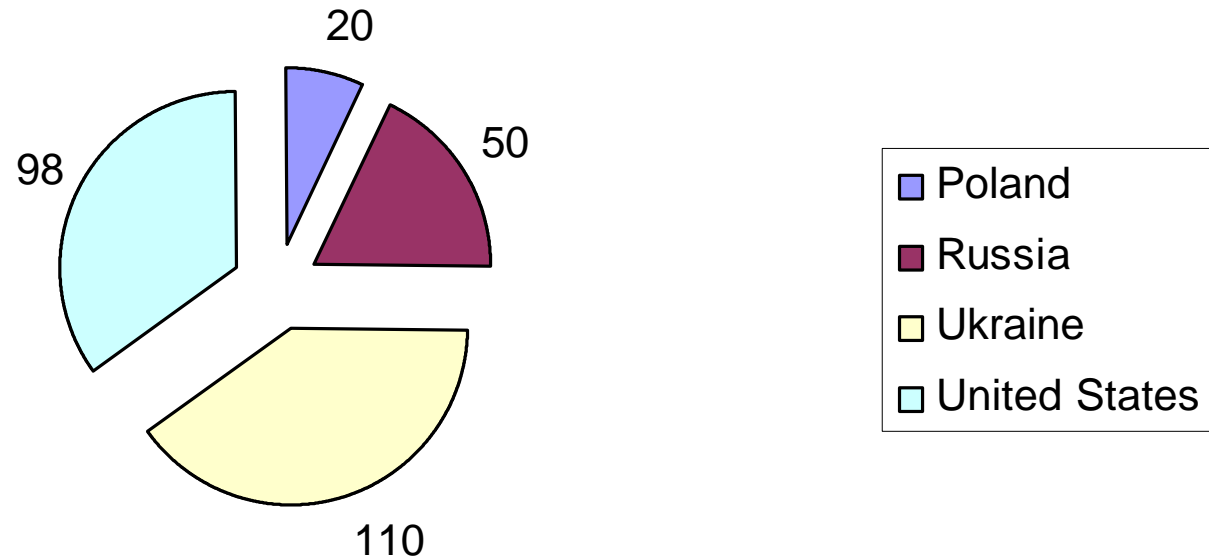
**Total is 758 MW at Active Mines**



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## ***POTENTIAL FUEL CELL POWER AT ABANDONED MINES IN SELECTED COUNTRIES***

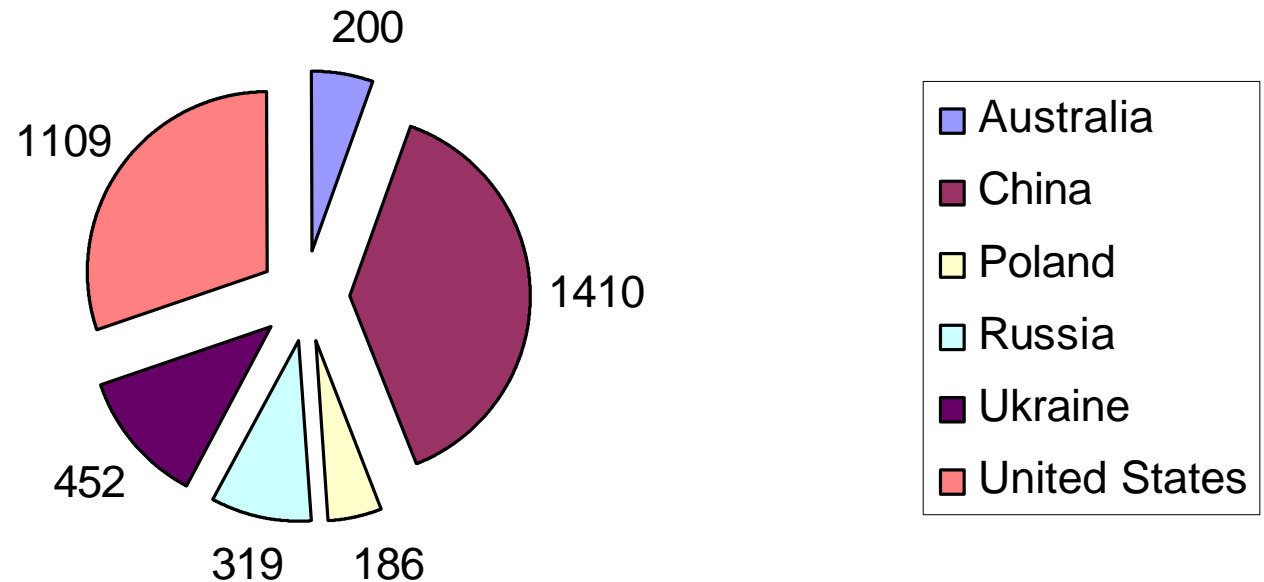
**Total 278 MW at Abandoned Mines**



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# ***POTENTIAL COAL MINE METHANE FUEL CELL CAPACITY (IN MW) WITH ENHANCED RECOVERY IN SELECTED COUNTRIES***

**Total is 3676 MW at Active Mines**



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# ***SUMMARY OF FUEL CELL POWER POTENTIAL UTILIZING COAL MINE METHANE IN SELECTED COUNTRIES***

<b>Country</b>	<b>Current Fuel Cell Potential at Active Mines</b>	<b>Current Fuel Cell Potential at Abandoned Mines</b>	<b>Enhanced Recovery Program Potential at Active Mines</b>	<b>Theoretical Market Potential at Active Mines</b>	<b>Quality of Coal Mine Methane</b>
	<b>(MW)</b>	<b>(MW)</b>	<b>(MW)</b>	<b>(MW)</b>	<b>% Methane</b>
Australia	30		200	300	16 – 90
China	183		1410	3700 - 6500	33 – 58
Poland	35	20	200	600	37 – 63
Russia	202	50	300	1900-2400	4 - 89
Ukraine	89	110	450		
United States	219	98	1100	2200	50 - 90+
<b>Total</b>	<b>758</b>	<b>278</b>	<b>3660</b>	<b>8700 - 12000</b>	



FuelCell Energy

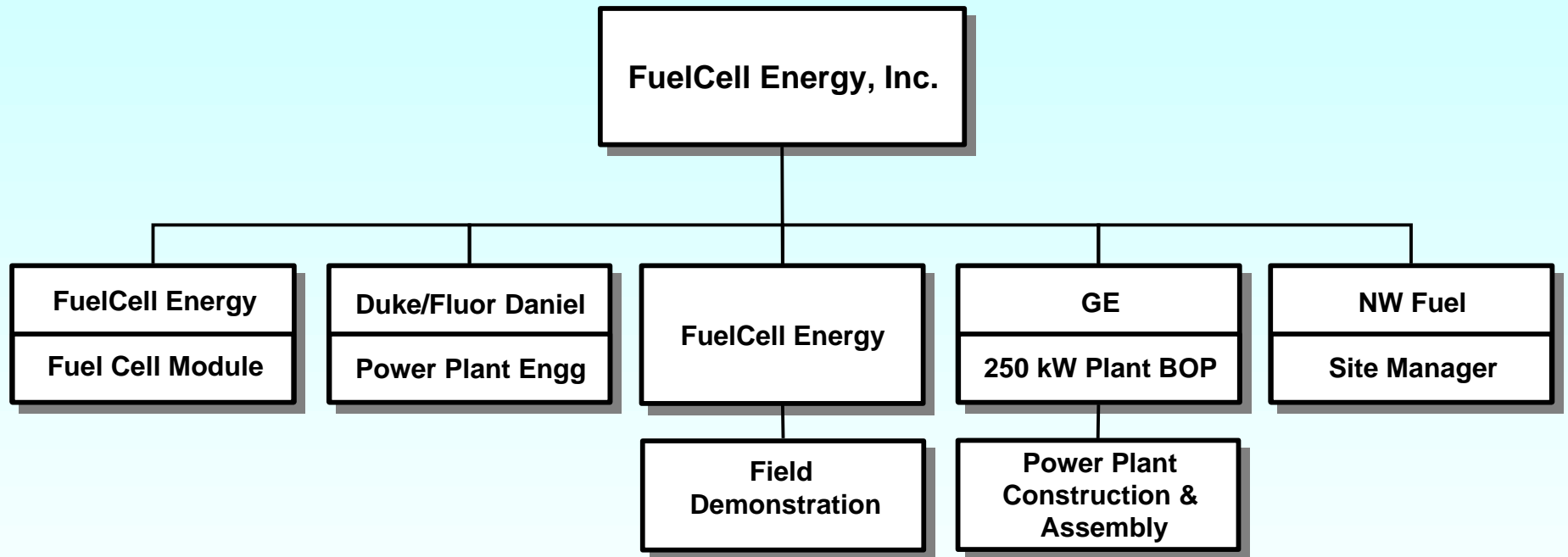
# ***WORLDWIDE FUEL CELL POWER POTENTIAL UTILIZING COAL MINE METHANE***

	Fuel Cell Potential	Fuel Cell Potential
	Low MW	High MW
China	3724	6517
CIS	1889	2367
United States	1410	2234
Poland	239	585
South Africa	319	904
India	160	160
Germany	399	479
United Kingdom	239	346
Australia	186	319
Czech Republic	106	186
Other Countries	905	1436
World Total	9576	15533



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# ***250 kW FUEL CELL DEMONSTRATION USING COAL MINE METHANE***



MO2486  
41900



FuelCell Energy

# ***PROJECT SUMMARY***

**Power Plant Size: 250 kW**

**Fuel Cell Type: Internally reforming carbonate fuel cell**

**Test Site: Rose Valley Site, Hopedale, Ohio**

**Harrison Mining Corp**

**Site Operator: Northwest Fuel Development, Inc.**

**Gas Quality: 60-70% methane**

**Gas Required: 36-43 scfm**

**Power Purchaser: American Electric Power**



**FuelCell Energy**



# ***ENVIRONMENTAL IMPACT OF 250 kW FUEL CELL DEMONSTRATION<sup>1</sup>***

## **Noise**

**60dB(A) at 10 meters**

## **Emissions**

**CO<sub>2</sub> (from typical natural gas)**

**235 lbs/h**

**NO<sub>x</sub>**

**<0.1 ppmv**

**SO<sub>x</sub>**

**<0.01 ppmv**

**CO**

**<10 ppmv**

**VOC**

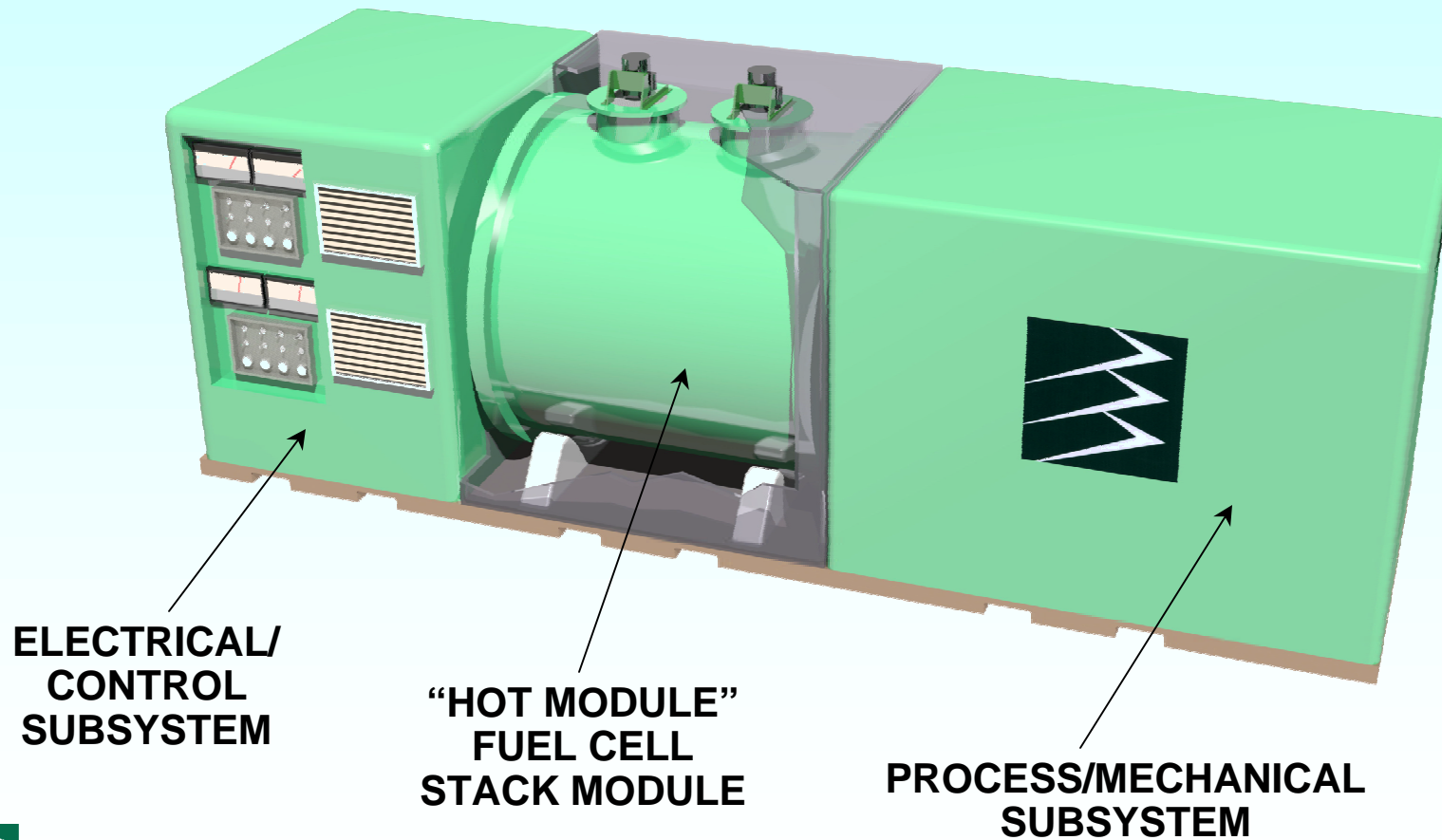
**<10 ppmv**

<sup>1</sup>BASED ON NATURAL GAS OPERATION



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# *250kW Fuel Cell Power Plant*



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## ***ROSE VALLEY SITE OF 250 kW FUEL CELL DEMONSTRATION ON COAL MINE METHANE NEAR HOPEDALE, OH***



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***ROSE VALLEY SITE OF 250 kW FUEL CELL DEMONSTRATION  
ON COAL MINE METHANE NEAR HOPEDALE, OH***



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# PROJECT SCHEDULE

Task Name	2000				2001				2002				2003			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1 NEPA Review and Planning																
Task 2 Final Design and Cost																
Task 3 Site Preparation and Test Plan																
Task 4 Plant Design, Construction, Testing																
Task 5 Site Restoration																
Task 6 Final Report and Technical Transfer																



FuelCell Energy

MO2609  
041701